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## (54) TWIN-SHAFT Z TYPE PROPELLING MEANS FOR A TUG BOAT

(71) We, NIIGATA ENGINEERING CO., LTD., a Japanese company, of No. 4-1, Kasumigaseki 1-chome, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a twin-shaft Z type propelling means for tug boats, and more particularly to such propelling means which can provide a propeller revolution speed slower than the speed that could be obtained at the minimum revolution speed of main engine, through slipping of a clutch means, thereby improving the manoeuvrability of the tug boat.

As is well known to those skilled in the art, tug boats much perform various specific functions such as standing change of front, lateral or astern movement and dead-slow going ahead or astern, in order to work in limited port area.

These functions have been performed, in conventional tug boats having so called Z type propelling means with twin shafts, by controlling the direction of thrusts of two shafts. Fig. 1 is a schematic illustration showing the manner in which conventional twin-shaft Z type propelling means are controlled to provide dead-slow operation. For dead-slow going, the propellers must be orientated to diverge as shown in Fig. 1 so as to relieve part of their thrusts outwardly, since dead-slow going is hard to effect when the directions of the thrusts coincide with the longitudinal direction of the hull.

By the term "twin shaft Z type propelling means" is meant a propelling means in which two propellers are supported on swivel mountings and connected with output shafting of a prime mover, means being provided whereby the propellers can be orientated on their swivel mountings to obtain a desired steering effect.

Referring to Fig. 1, reference numeral 1 designates a twin shaft Z type propelling means consisting of two propellers, each of which is adapted to generate thrust as represented by vectors  $F_1$ . The resultant thrust of these two components  $F_1$  is represented by a vector  $F$ . Thus, where the shafts are inclined at an angle  $\theta$  with respect to the longitudinal direction of the hull, the resultant vector  $F$  is given by the following equation.

$$F = 2F_1 \cos \theta$$

It will be understood, when the tug boat must be manoeuvred at a speed lower than that which could be obtained by vectors  $F_1$  which corresponds to the minimum speed of the main engine, the angle  $\theta$  is adjusted to provide fine adjustment of the resultant thrust  $F$ .

This way of controlling the thrust is, however, inconvenient in that the violent flow of water orientated laterally of the tug boat tends, for example, to sweep away small boats therearound, or make these boats crash into each other or cut fishing nets.

It is therefore an object of the invention to provide improved twin-shaft Z type propelling means for a tug boat in which dead-slow going is performed without changing the orientation of the propellers.

Another object of the invention is to provide an improved twin-shaft Z type propelling means which can be manoeuvred, over full speed and dead-slow speed, by handling only one lever.

According to the present invention there is provided a twin-shaft Z type propelling means for a tug boat, comprising a variable slip transmission means for connection between the main engine of the boat and the Z type propelling means, and control means for controlling, in operation, the amount of slip for said transmission means

when said main engine is operated at its minimum speed.

Generally, in the twin-shaft Z type propelling means provided by the present invention, the thrust force of the propellers is varied by controlling the amount of slip of a friction clutch provided between the main engine and propellers, thereby making it possible to obtain dead-slow operation without changing the orientation of the propellers. It is to be noted that, since only the required amount of thrust is generated by the propellers, the aforementioned eventual accidents by the water stream which have been inevitable with the conventional propelling means can fairly be avoided.

Further objects and advantageous features of the invention will become clear from the following description taken in conjunction with the accompanying drawings in which:—

Fig. 1 is a schematic illustration showing the manner in which conventional twin-shaft Z type propelling means are controlled to provide dead-slow operation.

Fig. 2 is a schematic illustration showing the manner in which twin-shaft Z type propelling means according to the invention are controlled to provide dead-slow operation.

Fig. 3 is a diagrammatic side elevation of one of the shafts of a twin-shaft Z type propelling means according to the invention.

Fig. 4 is a connection diagram to one of the shafts of a twin-shaft Z type means according to the invention.

Fig. 5 is a cross-sectional view of a friction clutch employed in the means according to the invention.

Fig. 6 is a diagram showing exemplarily the manner in which the output shaft is controlled.

Fig. 7 is a diagram showing the relationship between the revolution speed of the main engine and the horsepower absorbed by the propellers.

Referring to Fig. 2, there is shown schematically a twin-shaft Z type means according to the present invention; it will be seen that for dead-slow operation the orientation of the propeller shafts is parallel to the longitudinal direction of the hull and that the resultant thrust vector  $F$  of the individual thrust vectors  $F_1$ ,  $F_2$  is also parallel to the longitudinal direction of the hull.

Referring now to Fig. 3, in which there is shown one of the shafts of a means according to the present invention, reference numeral 3 designates an engine, the output of which is transmitted to an output shaft 5 through an input shaft 4 and a clutch 2. The output shaft 5 is provided at its end with a bevel gear 105 which engages another bevel gear 109 secured to the top end of a shaft 107. The shaft 107 is provided at its lower end with another bevel gear

111 which engages a bevel 117 on a shaft 115 of a propeller 113.

The shaft 107 and the bevel gears 111, 117 are covered by a cover 119, while the bevel gears 105, 109 are covered with another cover 121.

To the middle portion of the cover 119, is secured a worm wheel 123 enmeshed with a worm 127 arranged to be driven by a motor 125, through the medium of which the propeller 113 can be rotated through 360° about the shaft 107. The above described arrangement is a so-called Z type propelling means.

Referring now to Fig. 4 which schematically shows part of a twin-shaft Z type propelling means embodying the present invention, reference numeral 1 designates one of the Z-type propelling means, 2 designates a friction clutch; 3 designates a main engine; 4 designates an input shaft for the clutch 2; 5 designates an output shaft; 6 designates a manoeuvring handle; 7, 8 designate cams interlocked with the manoeuvring handle 6; 9 designates a micro switch for issuing signals for engaging and disengaging the clutch; 10 designates a control valve adapted to control the slip of the clutch 2; 11 designates a speed control valve for the main engine; 12 designates a source including a valve adapted to supply air to the valves 10, 11; 13 designates a clutch-actuating valve electrically connected to the micro switch 9 and connected to the slip control valve 10 through an air pipe; 14 designates an air conduit adapted to pass air from the slip control valve 10 to the clutch 2 through the actuating valve 13; 15 designates a speed control piston adapted to be operated by air from the speed control valve 11; and 16 designates a governor adapted for regulating the speed of the main engine.

Referring now to Fig. 5 which shows the clutch 2 in detail, the clutch 2 which is of pneumatic type comprises input and output friction discs 16, 17 which are provided between the input and output shafts 4, 5. A series of heat-radiating fins 18 are provided for radiating heat generated during the slipping of the discs. Numeral 19 designates a clutch piston which is communicated to the slip control valve 10 through the air conduit 14.

In operation, electrical signals are issued from the microswitch 9 upon operating the manoeuvring handle 6, and the clutch-actuating valve 13 is switched to ON so that air from slip control valve 10 gets into the clutch piston 19 which then pushes the friction discs 16 and 17. The arrangement is such that the force exerted by the air on the clutch piston 19 is varied as the slip control valve 10 is operated by the handle, thereby the contact pressure of two discs

16,17 is varied to provide different amount of slip.

It will be understood that the speed of revolution of the output shaft 5 can be varied with the speed of revolution of the input shaft 4 kept constant, due to the provision of the slip control valve 10.

This function, which is usually effected when the input shaft is at its minimum speed, constitutes the principal characteristic feature of the present invention. Namely, owing to this feature, it becomes possible to manoeuvre the boat at dead-slow speed without changing the orientation or direction of the Z type propelling means.

Referring now to Fig. 6 which shows as an example the manner in which the output shaft 5 is controlled by the manoeuvring handle 6, *a* shows the position of the handle where the clutch is disengaged, while *b* shows the position where the clutch is just engaged. It will be understood that the position *b* corresponds to the largest amount of slip of the clutch while *c* shows the position where the slip of the clutch is zero.

The speed of revolution of the main engine and the amount of the slip of the clutch is designated at *d* and *e*, respectively. The symbol *f* designates an area where the handle provides the minimum speed of the engine, while *g* designates the position at which the handle provides the maximum speed of the engine.

Fig. 7 shows the relationship between the speed of revolution of the main engine and the horsepower absorbed by the propeller, which horsepower varies according to the position of the handle 6. The symbols *b*, *c*, and *g* in Fig. 7 correspond respectively to those in Fig. 6.

Thus, in the range between *b* and *c*, the horsepower transmitted to the propeller is varied by changing the slip of the clutch, with the revolution speed of the main engine kept at minimum, while in the region between *c* and *g*, the clutch does not slip and the horsepower absorbed by the propeller is changed by changing the revolution speed of the engine.

It is to be noted that, although a specific embodiment has been described, the scope of the present invention is not limited thereto.

For example, any transmission means capable of providing variable slip, e.g. a hydraulic friction clutch, electro-magnetic clutch or hydraulic coupling, can fairly be used in place of the pneumatic clutch.

At the same time, it is possible to constitute the clutch such that the amount of the slip is increased as the force exerted by the clutch piston 19 increases, or such that the amount of the slip is decreased as the force of the clutch piston 19 increased.

#### WHAT WE CLAIM IS:—

1. Twin-shaft Z type propelling means for a tug boat, comprising a variable slip transmission means for connection between the main engine of the boat and the Z type propelling means, and control means for controlling, in operation, the amount of slip for said transmission means when said main engine is operated at its minimum speed.

2. Twin-shaft Z type propelling means as claimed in Claim 1, wherein said transmission means is a friction clutch arranged to change the amount of said slip as the pressure of a fluid supplied thereto is varied.

3. Twin-shaft Z type propelling means as claimed in Claim 2, wherein said clutch is provided with heat-radiating fins for radiating heat generated during the slipping of clutch discs of said clutch.

4. Twin-shaft Z type propelling means as claimed in Claim 1, 2 or 3, wherein said control means comprises a clutch actuating valve, a slip control valve and an air supply source.

5. Twin-shaft Z type propelling means substantially as hereinbefore described with reference to and as illustrated in Figs. 2 to 5 of the accompanying drawings.

6. A tug boat provided with twin shaft propelling means according to any one of the preceding claims.

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